

ECE 403
Conceptual Design and Options
Considered

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Introduction

SmartLight is an intelligent light switch. The purpose of SmartLight is to add functionality and feedback in place of a traditional home light switch. Using an Android-based system the user would be able to monitor power usage, power usage statistics, generate reports, and schedule the switch to turn on and off, all the while being an intuitive and attractive light control. In addition to these features the device should allow easy transmitting and receiving of data from common smart devices for wireless monitoring purposes and wireless control while fitting in a traditional light switch space. The graphical interface on the product will be easy to use for users of any technical skill level. The ultimate goal of this device is to promote energy conservation by making monitoring and controlling energy use easier and more enjoyable at a reasonable cost.

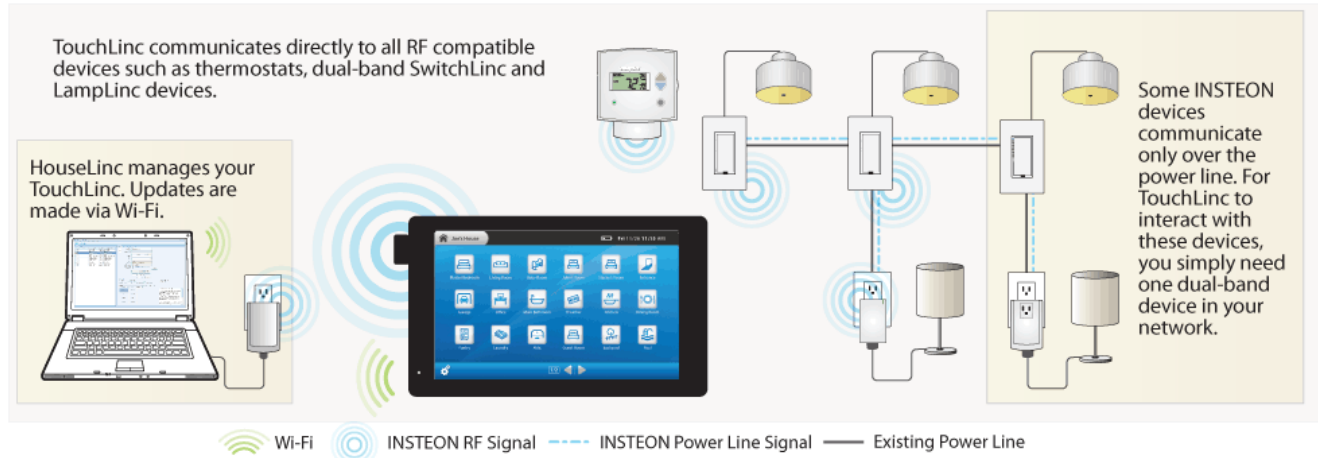
Previous Work

Smart Home Light Control Devices



The SmartHome TouchLinc is a touch screen home control device that can sync with lights and outlets in a home through the SmartHome INSTEON system. This system is capable of turning on and off lights, dimming lights, and setting up user controlled events through WiFi and RF communication with other in home equipment. TouchLinc also gives the user a simple and custom programmable user interface for turning lights off and on throughout a home.

SmartLight's goal is somewhat similar to TouchLinc, however, SmartLight would be a more affordable, interactive, and relevant product powered by Android. The basics of TouchLinc would form the basis of our product with differences in the user feedback and scope. Where TouchLinc uses RF to communicate with in home products, our group plans to use WiFi. Another main difference is the use of Android, which is open source and can have many developers and new features being added all the time, instead of a closed private operating system.







Electronic / Touchscreen Dimmer

Another aspect of SmartLight is an easy to use touch screen interface capable of complete light control and giving feedback to the owner. A product that is slightly similar to this idea is the Insteon Electronic Dimmer. This switch gives the user a comfortable, attractive, and touch screen dimmer feature. It also includes an RF receiver and transmitter that is capable of providing feedback through a central hub in the house. This product is another inspiration for SmartLight.



Although similar in idea, SmartLight plans to take the above two products and merge them together a small product that allows placement in any room in a building using Android and a micro controller for a number of possible inputs and outputs. Using android and a micro controller opens the door for all kinds of possibilities, including; apps, WiFi connectivity, and an intuitive touch screen interface.

Below is a table of similar products found and links to their websites.

Information	Image/PriorArt/Concepts
<p>Insteon - Using electrical wires in the home, as well as using radio frequency for communication channels between multiple devices. They are our biggest competitor http://www.insteon.net/</p>	
<p>Insteon Electronic Dimmers - http://www.smarthome.com/_Dimmers_Lighting_Appliance_Control/Dimmers_Wall_Switches_Key pads_Touchscreens/INSTEON/_/z/1QV/23b/nav.aspx</p>	
<p>Insteon Touchscreen Controller - http://www.smarthome.com/2490C7/TouchLinc-INSTEON-Wireless-Touchscreen-Controller-Kit/p.aspx</p>	
<p>Insteon Electronic Communicator Power Switch - http://www.smarthome.com/2412N/SmartLinc-INSTEON-Central-Controller/p.aspx?green=98E1BEB6-B7B2-5A97-05B4-AC6D5E1969B7</p>	

Design Options Considered and Selected Approach

Goals

Before we considered ways to achieve our project we first needed to establish goals. From these goals we discussed a few ideas before selecting SmartLight. Main goals to accomplish consisted of:

- Using a touch screen interface device in the home to control lighting and provide feedback to the user.
- A micro controller to provide input and output options for the user that is capable of communicating with the touch screen device.
- An AC/DC converter is necessary to power the electronic devices with power from the wall.
- User feedback through the micro processor would be handled through additional sensors.

Options Considered

Hardware

The device would be implemented using an ADK (Android Development Kit) based platform so the Android device can communicate with the hardware that will control the light/outlet. Two platforms we found that would work are Arduino and IOIO. Both are viable options because they support Android Open Accessory which allows the Android device to perform read/write operations to the microcontroller. The microcontroller would be used to monitor current draw and control the light.

Communication

The Android device would communicate with the microcontroller using Wi-Fi. Both the Arduino and the IOIO have on-board Wi-Fi that is designed to easily connect to any Android device on the same local area network. Other options that were considered were X10 and RF communications. Wi-Fi was chosen for the sake of convenience and signal stability. X10 communicates over the electrical wiring in your home and would allow separate SmartLights in the house to communicate with each other with no need for an internet connection, however, Wi-Fi would still be required for the Android device to communicate with the modules. RF communication would be possible, but not be used for the same reasons. The only way the Android device can communicate with the module is using Wi-Fi, so it is best that all the modules in the house would be connected to the device that way.

Software

Software will be handled for the user interface strictly through Android and java. Using data from the microprocessor the software will be designed to provide real time feed back of microprocessor inputs in an attractive display on the touch screen device. C will also need to be utilized for programming the microprocessor. The microprocessor will be responsible for sensor feedback and relaying the information to the Android system.

Interface Device

To meet the first goal of using a touch screen interface that provides feedback to the user, adjusts the lighting controls of the room, and has an easy and attractive GUI we considered

several options.

The first was a generic MP3 player. This was considered for a couple main reasons of affordability and availability. However, we ended up not choosing this option because almost every MP3 player has its own operating system as well as a steep learning curve to be able to develop code for the device.

The advantages:

- Affordable
- Available
- Wide selection to choose from

The disadvantages:

- Each one has a unique operating system
- Many features besides music playback might be hard to develop on some MP3 players
- Little to no development support for third party developers

Another option considered was a tablet device of some sort. The group planned on utilizing its increased size to make the device more capable and attractive. However, this would require actual construction around a light switch to make room for a tablet which we wanted to definitely avoid. It was ultimately decided that the bulkiness and cost of a tablet would be too much.

The advantages:

- Capabilities
- Multiple Choices
- Screen Size

The disadvantages:

- Cost
- Too large to fit in a light switch

The third and final choice that the group debated on was using a phone. After some consideration it became our final choice. The reasons for choosing a phone were numerous. A smart phone running android has WiFi capabilities, an attractive touch screen display, roughly a light switch size, and android capabilities. Android was also another strong suit because of the strong third party support available from google and other groups. These aids will help development immensely.

The advantages:

- Affordable
- Available
- Android (Strong support and help documents online)
- Size
- Potentially all the capabilities of a smart phone
- Attractive touch screen displays

The disadvantages:

- Each one has a unique operating system
- Many features besides music playback might be hard to develop on some MP3 players

- Little to no development support for third party developers

Microcontroller

In order to use the Android device to control the light and monitor current readings, we will need a microcontroller external to the device to interface with the switching and monitoring hardware and communicate with the Android device.

The Arduino platform was initially considered because it has the ability to communicate with the Android device using Android Open Accessory via USB and/or Wi-Fi, but was later ruled out because a cheaper and smaller sized platform was discovered.

The advantages:

- Available
- Android Open Accessory makes communication easy

The disadvantages:

- Large size
- Expensive
 - Programming required
 - Unnecessary features for our application

The other platform that we considered was the IOIO board. We chose this for our application due to its reasonable price and very compact size. It supports Android Open Accessory, just as the Arduino board did, so it will be able to communicate to the Android device easily.

The advantages:

- Available
- Android Open Accessory makes communication easy
- Small size
- Affordable
- No programming required

The disadvantages:

- Unnecessary features for our application
- Only power connection is via USB

Light controlling hardware

The light will need to be controlled by switching it on and off as well as dimming. We also intend to monitor the current draw from the light when it is in use so the user can easily keep track of how much electricity they are using. This circuitry will need to be powered by a 5V DC source in order to function properly.

We need a way of triggering a switch to turn the light on and off. Our selected approach is using a relay to open and close the circuit connecting the light to AC power. The IOIO micro will send a logic signal to the relay to engage/disengage the switch.

The advantages:

- Easy to use
- Minimal current draw when light is off

- Capable of handling large currents

The disadvantages:

- Expensive
- Slow switching time

Options Considered Summary

Touchscreen WiFi Light Switch Controller - Selected

- Relay switches:
 - <http://search.digikey.com/us/en/products/7150-05-1000/7150-05-1000-ND/710345>
 - Dimming option - **Selected**
- AC/DC Converter
 - Buy online - **Selected for convenience and**
 - Design and build in-house
- Current monitoring:
 - Hall-effect current sensor - **Selected**
 - <http://search.digikey.com/us/en/products/ACS756SCA-100B-PFF-T/620-1238-ND/1829841>
 - Shunt resistor
 - <http://www.maxim-ic.com/app-notes/index.mvp/id/746>

SmartSwitch Basic (Switch Only w/WiFi)

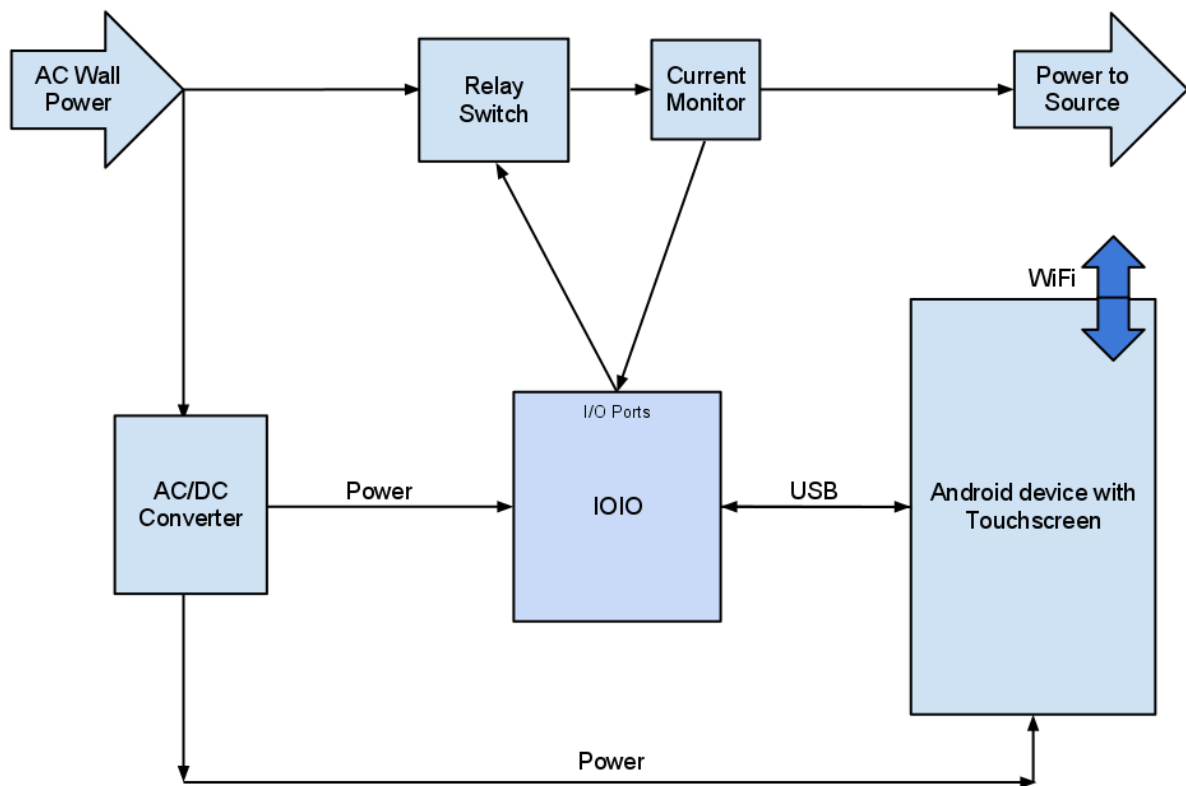
This option would allow the user to control a switch from their mobile device from anywhere in the house, but the switching module would have no display. The Basic would be a cheap and flexible switch that can be installed in any location throughout the house with AC wall power. This switch would then be able to be controlled by any Android device with the user software installed.

The advantages:

- Lower material cost, making it more marketable
- Simpler design allowing us to make it more efficient

The disadvantages:

- Limited functionality, a less robust project
- No built-in display
- Similar competitive products exist
- Not stand-alone, requires wireless mobile connectivity



Budget

Part	Quantity	Cost per unit	Part number	Details
Android device	1	\$60	LG Optimus S	Swappa.com - http://swappa.com/buy/lg-optimus-s-sprint
Relay	1	\$1.27	G5T-1A DC5	Digikey - http://search.digkey.com/us/en/products/G5T-1A%20DC5/Z2774-ND/1731474
Hall-effect current sensor	1	\$6.44	ACS756SCA-100B-PFF-T	Digikey - http://search.digikey.com/us/en/products/ACS756SCA-100B-PFF-T/

				620-1238-ND/1829841
Enclosure	1	To be determined	To be determined	Utilize the 3D printing machine in ECE department
IOIO board	1	\$49.95	DEV-10748	Sparkfun - http://www.sparkfun.com/products/10748
AC/DC converter	1	\$2.95	POL-AFACDC-LGOPTIMUSS	cell-phone-accessories.com - http://www.cell-phone-accessories.com/lg-optimus-s-ac-dc-converter.html
USB cable	1	\$3	Micro USB Data Charger Cable	Ebay - http://www.ebay.com/itm/Micro-USB-Data-Charger-Cable-HTC-Droid-Incredible-/150660600313?pt=PDA_Accessories&hash=item23141251f9#ht_2749wt_1346
Total material cost:		\$123.61		This does not include cost of enclosure

Timeline

(See attached)

Summary

In conclusion, the SmartLight will achieve the following four main goals:

- Using a touch screen interface device in the home to control lighting and provide multiple feedback options to the user.
- A microcontroller to provide input and output options for the user that is capable of communicating with the touch screen device.
- An AC/DC converter is necessary to power the electronic devices with power from the wall while allowing AC current to pass through to in-house devices.
- User feedback through the micro processor would be handled through additional sensors.

Options for achieving these goals were weighed and decided on. As a group we came to a conclusion on each main goal that will comprise SmartLight. Firstly, to cover a touch screen interface that can display feedback to the user as well as allow additional functionality to separate it from competitors SmartLight will use a touch screen Android phone, specifically an LG Optimus S. The second objective was to utilize a microcontroller to allow interaction with other devices through inputs and outputs that would then communicate back to the Android phone. An IOIO board from Sparkfun was chosen because it provides all the needed input and outputs functions, is small, and can communicate with the phone through USB.

Finally additional sensors are available to add because of the strong development support through android as we continue with the project. Currently power consumption through a current reading device (Hall Sensor) is planned. The total cost of SmartLight is expected to be about In the end; we feel SmartLight will be a light switch for the future. With the current light switch used in most homes dating back decades, SmartLight aims to replace a device everyone uses. Using the solutions our group found we will be able to implement a switch that provides more than just off and on or dimming features of a traditional light switch. These abilities will still be available but now through an attractive touch screen device. SmartLight will give the owner the unique ability to monitor power consumption through a room, use WiFi connectivity, and put Android in a light switch - allowing hundreds of possibilities in the future.